Losses in the transportation of fruits and vegetables: revisiting a Brazilian case study model[1]

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Introduction

According to Caixeta-Filho (1999), there are several transportation models applied to Brazil, documented by the international literature. The two pioneering ones (Lave et al., 1966, for the Northeast region; and Whitman, 1968, for the Southeast region), were inspired under normative approaches, and had as the main objective the identification of feasible transport projects, as well the evaluation for an entire mode or sector through the application of a formal network model. Linear programming was the technique used to basically determine for each commodity the pattern of shipments from sources to sinks that results in the lowest total transportation cost. Both of them do not pay attention to the eventual losses in the transportation, except for the treatment given by Whitman (1968) to the increase on vehicle operating costs due to the variations of road surface type, vertical profile, horizontal alignment and side clearances.

Also according to Caixeta-Filho (1999), the majority of Brazilian goods flow through the country by road transport, with the occurrence in some years of more than 90% of the agricultural production being transported by trucks. The statistics about losses vary, according to the source, to the cause and to the eventual methodology to measure them. According to Borges (1992), the Brazilian situation, in terms of losses, is not different from the other developing or less developed countries. They account, in general terms, for something around 30%, achieving rates between 80 and 100% for the more perishable products, such as some fruits and vegetables.

Objectives

The purpose of this abstract is to revisit the model proposed by Caixeta-Filho (1999) and to discuss the potential for its replication to other situations and other agricultural products. The model was originally proposed for the logistics of fruits and vegetables. However, we believe that the model can be adapted to different situations and agricultural segments.

Methods

To model the problem of losses in the transportation of fruits and vegetables, two basic aspects have to be taken into consideration by Caixeta-Filho (1999): it is not a very clear phenomenon, either under the logistic or the biological and chemical view; and that there is no consensus in the pertinent literature that those losses have to be minimized.

Thus, the treatment to be given to losses in the transportation in his study considers that: a) the road conditions are fundamental when considering the distance to be driven. Therefore, adjustment factors are assumed as a mean of homogenizing distance values for different types of road surface, by vehicle type; b) the level of losses varies according to the logistic option to be utilized. Caixeta-Filho (1999) stated that there were also distinct costs associated to each of those logistic options. These functions and the respective costs for them were therefore incorporated in his analysis.

In view of that, a normative approach was apparently demanded and it seems that the use of mathematical programming techniques was the most appropriate one for the treatment of the problem. The problem was formulated as one of maximizing the wholesalers' surplus observed in the trade of each specific product, taking into consideration the possibility of having available

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supplies of technological options for diminishing losses. This would then imply the determination of: shipment patterns between supply and demand regions for agricultural products; prices to be paid to the producers; pertinent consumers' prices; and damage prediction during the transportation of each type of product. The required data were basically associated to: supply and demand functions; transport cost functions; loss functions; and the distances between the regions. Thus, the following mathematical structure, of quadratic complexity, was proposed as shown in Figure 1:

$$Max\ \mu = \sum_{i=1}^{n}\sum_{j=1}^{o}\sum_{k=1}^{p}\sum_{l=1}^{q}\sum_{m=1}^{r}\left(DP_{jk}Y_{ijklm} - SP_{ik}X_{ijklm} - c_{ijklm}X_{ijklm}W_{ijl} - e_{ijklm}X_{ijklm}\right) \quad (1)$$

subject to:

$$\sum_{j=1}^{o}\sum_{l=1}^{q}\sum_{m=1}^{r}Y_{ijklm} \leq S_{ik}\ , \qquad for\ i = 1, 2, \ldots, n;\ k = 1, 2, \ldots, p \qquad (2)$$

$$\sum_{i=1}^{n}\sum_{l=1}^{q}\sum_{m=1}^{r}Y_{ijklm} \geq D_{jk}\ , \qquad for\ j = 1, 2, \ldots, o;\ k = 1, 2, \ldots, p \qquad (3)$$

being:

μ = total wholesalers' surplus observed between the total demand and total supply values;

SP_{ik} = price paid for the product *k* to the producer at region *i*;

DP_{jk} = demand price for the product *k* at region *j*;

X_{ijklm} = amount of the product *k* to be transported from *i* to *j*, with the vehicle type *l* and using the packaging pattern *m*;

Y_{ijklm} = effective amount of the product *k*, with the packaging pattern *m*, that arrives at the demand region *j*, from the supply region *i*, using the vehicle type *l*;

c_{ijklm} = unit transport cost to move product *k*, packaged under the pattern *m*, with the vehicle type *l*, from *i* to *j*;

e_{ijklm} = other expenses (unloading, wholesaler's commission, etc.) related to the supplied product *k*, packaged under the pattern *m*, with the vehicle type *l*, from *i* to *j*;

S_{ik} = supply of the product *k* by the region *i*;

D_{jk} = demand for the product *k* in the region;

W_{ijl} = weighed distance between *i* and *j*, using vehicle type *l*.

Figure 1. The proposed model.

Caixeta-Filho (1999) also states that those variables could be transformed following some approximations and assumptions.

The mathematical model proposed was processed using GAMS (General Algebraic Modeling System). As a mean of illustration, Caixeta-Filho (1999) applied his model to the trade of two of these commodities - pineapple and tomato - in the São Paulo State, using data taken from a cross-section of the trade occurred during 1993 in the Ceagesp (Companhia de Entrepostos e Armazéns Gerais de São Paulo), the main wholesale market in São Paulo city, in Brazil.

Results

The results obtained by the model were quite elucidative and consistent. The model proposed by Caixeta-Filho (1999), tried to contribute proposing a normative transportation model that incorporates the possibility of assessing losses due to the specific characteristics of the transportation system utilized, namely the road conditions, specialized equipment and packaging patterns. At that time, he faces several limitations, especially related to the unavailability of data. Anyway, the model has adequate grounding in economic theory and robust mathematical structure. The results obtained at the time demonstrated the potential of the model.

However, the concern of the author was also related to the distance from Transport Economics field to the Development Economics field, which are still both far away from the experiments conducted by the Agricultural Engineering and Science fields. This may explain, at least in part, to the lack of availability of technical parameters available to feed the model.

Conclusions

We conclude that the model has plenty of conditions to be adapted to other situations, segments and agricultural products. Research and development projects that focus on the building of optimization models to minimize losses, and that focus on the systematic collection of information from the field is also needed.

References

Borges, R. F. Panela furada: o incrível desperdício de alimentos no Brasil. São Paulo, Columbus, 1991, Coleção Cardápio, v.7. 124p.

Caixeta-Filho, J. V. Losses in the transportation of fruits and vegetables: a Brazilian case study. International Journal of Logistics, v.2, n.3, p. 325-341, 1999.

Lave, R. E., Jr. and Kyle, D. W. A systems study of transportation in Northeast Brazil. Stanford University, Institute in Engineering Economic Systems, March 1966. 82p.

Whitman, D. A computerized transportation planning model with application to Brazil. Los Altos, California, SYSTAN, Inc. (SPR68-6), August 1968.